REGULATING
NUCLEAR FUEL WASTE

Atomic Energy Control Board
Commission de contrôle de l'énergie atomique

Canada

Contents

Regulating Nuclear Fuel Waste INFO - 0537(E)

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The Atomic Energy Control Board is the regulatory body that controls the health, safety, security, and environmental aspects of the production and use of nuclear energy and radioactive materials in Canada.

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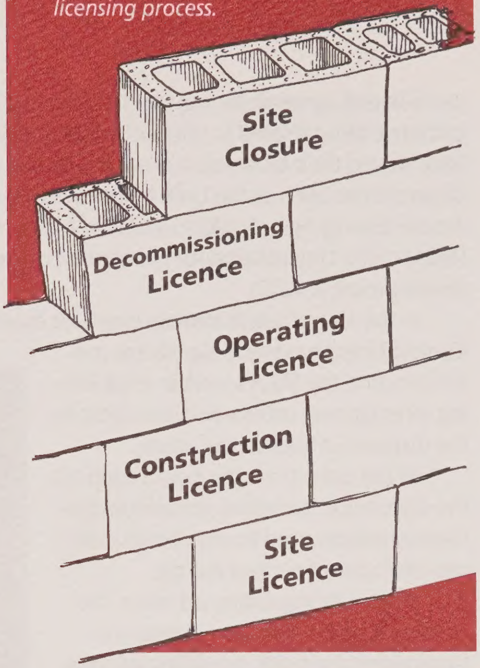
Controlling nuclear energy

Summary

- The Atomic Energy Control Board regulates all aspects of nuclear energy in Canada to ensure there is no undue risk to health, safety, security or the environment. It does this through a multi-stage licensing process.
- The Control Board maintains an open and transparent approach to its responsibilities as a regulator and is responsive to public concerns. Its priority is to protect nuclear workers and the public from radiation, and to protect the environment.
- After considering the most important safety issues related to deep geologic disposal of nuclear fuel waste, the Control Board developed criteria and regulatory requirements that would ensure a high level of protection to the public, now and in the future.
- Satisfactory methods exist for determining whether a specific disposal concept will comply with these safety criteria and requirements, even over long periods of time.
- The Control Board will assess the geologic disposal concept being considered for use in Canada against its criteria. It will report its findings to the Environmental Assessment Panel which was set up by the government to review the safety and environmental impact of the concept.
- If the government approves the concept, the Control Board will subject any actual disposal facility to its licensing process.

Control: *The Atomic Energy Control Board regulates nuclear activities in Canada through a multi-stage licensing process.*



Introduction

When Parliament passed the Atomic Energy Control Act in 1946, it erected the framework for nuclear safety in Canada. Under the Act, the government created the Atomic Energy Control Board and gave it the authority to make and enforce regulations governing every aspect of nuclear power production and use in this country.

The Act gives the Control Board the flexibility to amend its regulations to adapt to changes in technology, health and safety standards, co-operative agreements with provincial agencies and policy regarding trade in nuclear materials. This flexibility has allowed the Control Board to successfully regulate the nuclear industry for more than 40 years.

Its mission statement — *to ensure that the use of nuclear energy in Canada does not pose undue risk to health, safety, security and the environment* — concisely states the Control Board's primary objective.

Directing activities

Five persons chosen by the government for their scientific knowledge and experience serve as members of the board to direct the agency's activities. One of these board members is the full-time president and chief executive officer. The other four serve part time, meeting with the president about eight times a year to make licensing decisions and discuss policy and management issues.

The board is supported by a staff of about 400, including specialists in reactor regulation, fuel cycle and materials regulation, research, radiation and environmental protection, planning and administration.

The Control Board also maintains links with international organizations that conduct research, set standards, enforce

multi-lateral agreements, provide technical assistance and exchange ideas related to nuclear energy. Members of its staff have shared their technical and administrative expertise with organizations such as the United Nation's International Atomic Energy Agency (IAEA) and the Nuclear Energy Agency (NEA) of the Organization for Economic Co-operation and Development (OECD).

In the area of waste management, for example, the Control Board has made significant contributions to the IAEA's work in establishing international criteria and standards for the disposal of nuclear fuel waste.

At the same time, the Board supports the diplomatic, technical and administrative techniques used to discourage non-peaceful uses of nuclear energy.

In all of its regulatory activities, the Control Board maintains an open and transparent approach, providing information to the public on request and responding to public concerns.

Mission STATEMENT

To ensure that the use of nuclear energy in Canada does not pose undue risk to health, safety, security and the environment.

Regulation through licensing

To regulate nuclear activities, the Control Board depends on its formal, multi-stage licensing process and inspection program. At each stage of a project, applicants or licensees must demonstrate to the Board that nuclear workers, the public, and the environment, will be protected against the effects of radiation.

In summary, the Control Board is authorized to:

- Establish regulations and performance standards for all nuclear activities.
- Issue licences after applicants demonstrate they can meet performance standards.
- Inspect nuclear operations to ensure licensees comply with the terms of their licence.
- Amend, suspend, or revoke licences for non-compliance.
- Instigate prosecution of persons or organizations for infractions of regulations.

Throughout the stages of the licensing process, from site selection through to closing down a nuclear facility, applicants must provide detailed information to show their ability to meet required health, environmental and safety standards. The Control Board bases its standards on internationally accepted rules of good practice, dose limits, emission limits and other safeguards.

The most basic form of protection is a limit on the annual radiation dose for nuclear industry workers. The Control Board has set this limit at a level low enough to avoid acute injury and to ensure that health effects, if any, will be comparable to job-related risks in other relatively safe industries. It established an even larger margin of safety for the general public. The maximum allowable dose to the public from nuclear activities is a small fraction of that for workers in the industry. In the case of nuclear waste disposal, the limit is even lower.

Regulating waste management

Like other nuclear activities, radioactive waste management is regulated by the Atomic Energy Control Board.

The Control Board strictly controls the handling, transportation and storage of all radioactive wastes that could adversely affect human health or the environment. It will also closely regulate their ultimate disposal at appropriate facilities.

Because used nuclear fuel is the most hazardous and longest lived of all radioactive waste, the governments of Canada and Ontario decided to assess the idea of disposing of this material in a repository built deep in the Canadian Shield. In 1978, they introduced the Nuclear Fuel Waste Management Program under which this assessment would be conducted. Atomic Energy of Canada Limited (AECL) was appointed the lead agency to develop the concept and the associated technologies needed to implement it. It began this work in 1979.

A decade later, the federal government appointed a seven-member Environmental Assessment Panel to review the safety, environmental, social, and economic implications of the disposal concept. The Panel is drawing on members of the Canadian scientific community to provide a technical evaluation of the research work conducted by AECL. But, through a series of public hearings, a much broader spectrum of Canadians will be invited to comment on all aspects of the concept, including social, ethical and economic issues.

The Panel will make its recommendations to the federal government.

Meanwhile, the Control Board has been carefully considering the critical safety issues related to the geologic disposal concept and has developed criteria and regulatory requirements to address them. The objective of these criteria and requirements, which are comparable with those recommended by international agencies and applied by other countries, is to protect the public and the environment from any unacceptable radiological effects of waste disposal, now or in the future.

The Control Board has concluded that satisfactory techniques exist for demonstrating how well a specific disposal

concept will comply with these safety criteria and requirements, even over very long periods of time. These techniques can take into account the uncertainties that exist, making it possible to arrive at appropriate regulatory decisions.

Consequently, the Control Board will assess the environmental impact statement on the geologic disposal concept currently being considered for Canada against its criteria and requirements, and will report its findings to the Environmental Assessment Panel.

It should be noted that the Control Board does not have a licensing role in the concept assessment phase of the current program. If the government finds the concept acceptable, however, the Board will finalize its criteria and requirements in preparation for any licence applications it receives for siting, constructing, operating and closing an actual nuclear fuel waste disposal facility.

Safeguards and nuclear fuel waste repositories

Since 1945, Canada has actively campaigned to discourage non-peaceful uses of nuclear energy. It was instrumental in creating the International Atomic Energy Agency (IAEA) in 1957 and was one of the first countries to sign the Treaty on the Non-Proliferation of Nuclear Weapons (NPT).

One of the IAEA's functions is to carry out safeguards in each of the countries that have signed the NPT. Safeguards is a system of verification that includes measures designed to ensure that nuclear material is not diverted to nuclear weapons or nuclear explosive devices.

The Control Board administers the safeguards agreement between Canada and the IAEA, facilitating IAEA inspections of safeguarded nuclear material in Canada.

All nuclear material in Canada is subject to safeguards under the *Agreement Between Canada and the IAEA for the Application of Safeguards in Connection with the Treaty on the Non-proliferation of Nuclear Weapons*. Nuclear material in a Canadian nuclear fuel waste repository will therefore be subject to such safeguards.

It is generally accepted, however, that nuclear material in a repository will require safeguard approaches that are different from those applied at nuclear facilities where the nuclear material is accessible. Consequently, methods to apply satisfactory safeguards to nuclear fuel waste repositories are currently under international discussion.

Where radioactive waste originates

Summary

- Radioactive waste is a small part of the overall waste problem facing the world, but requires careful management because its radiation can harm life and the environment, and because some elements continue to emit radiation for thousands of years.
- Management systems for all types of radioactive waste already exist. Currently, however, the most potentially dangerous radioactive waste — used fuel from CANDU reactors in Ontario, Quebec and New Brunswick — lies in storage. Systems for disposing of this type of waste are being studied in Canada and many other countries.
- The volume of existing nuclear fuel waste in Canada is comparatively small. It would all fit into a few Olympic-size swimming pools.

Introduction

In Canada, radioactive waste originates at uranium mines and mills, at plants that make fuel for nuclear reactors, at the reactors themselves, and at industrial sites, hospitals, research laboratories and other facilities that use nuclear energy and radioactive substances.

Although radioactive waste is a small part of a much larger waste management issue, it is unique in several ways:

- It cannot be chemically treated to remove its radiation.
- Unlike many waste products that remain hazardous forever, all radioactive waste does decay — most of it quickly, some of it over thousands of years — and it eventually becomes harmless from the radiological standpoint.
- Regulated quantities of radioactive waste can be disposed of only if conditions set by the Atomic Energy Control Board are met — conditions designed to protect the environment and human health, and to minimize any burden on future generations to look after it.

***Fuel waste:* Nuclear fuel waste consists of used fuel bundles, each about the size of a fireplace log.**

- Conditions for radioactive waste disposal are generally more strict than the controls on other hazardous substances now discarded in the environment.

Two classifications

The Canadian nuclear community recognizes two classifications of radioactive waste: high-level and low-level. Uranium mine tailings are another type of waste, but are not discussed in this brochure.

High-level radioactive waste consists of the used fuel from reactors. Used fuel is referred to as nuclear fuel waste.

Low-level waste includes used medical and industrial radioisotopes; contaminated clothing, rags, mops, scrap, tools, paper and other items from nuclear reactor sites and other nuclear facilities; and historic wastes from activities that predate effective control of radioactive materials. Low-level waste typically contains a small amount of radioactivity dispersed in a large amount of material.

The radioactivity levels of this material are either very low to begin with, or will become so in a relatively short time compared to those of nuclear fuel waste. Most of this material is stored in protected above-ground (or just below-ground) engineered facilities. The Atomic Energy Control Board regulates and licenses the design, construction and operation of such facilities.

About nuclear fuel waste

CANDU reactors use rods of uranium dioxide fuel packed in 20-kilogram bundles, each the size of a fireplace log and each capable of generating enough energy to heat a home in northern Canada for about 100 years.

When fuel bundles are new, their radioactivity level is low and they can be held in the hands. After 18 months inside a

reactor, however, a small percentage of the uranium dioxide has undergone a change. This change renders the bundles inefficient as fuel and makes them so radioactive that they must be moved to nearby storage facilities by remotely controlled equipment.

Storage has proven safe and economical for more than 30 years, but requires continual monitoring, maintenance and security provisions. These measures would be impractical to maintain indefinitely.

Canada initiated the Nuclear Fuel Waste Management Program to develop a way to safely dispose of the used nuclear fuel bundles discharged from commercial power reactors located in Ontario, Quebec and New Brunswick. Although each reactor contains thousands of such fuel bundles, the total volume of fuel waste in existence is relatively small. It is estimated that if a disposal facility were built, it would hold all the nuclear fuel waste produced by Canada for up to 100 years.

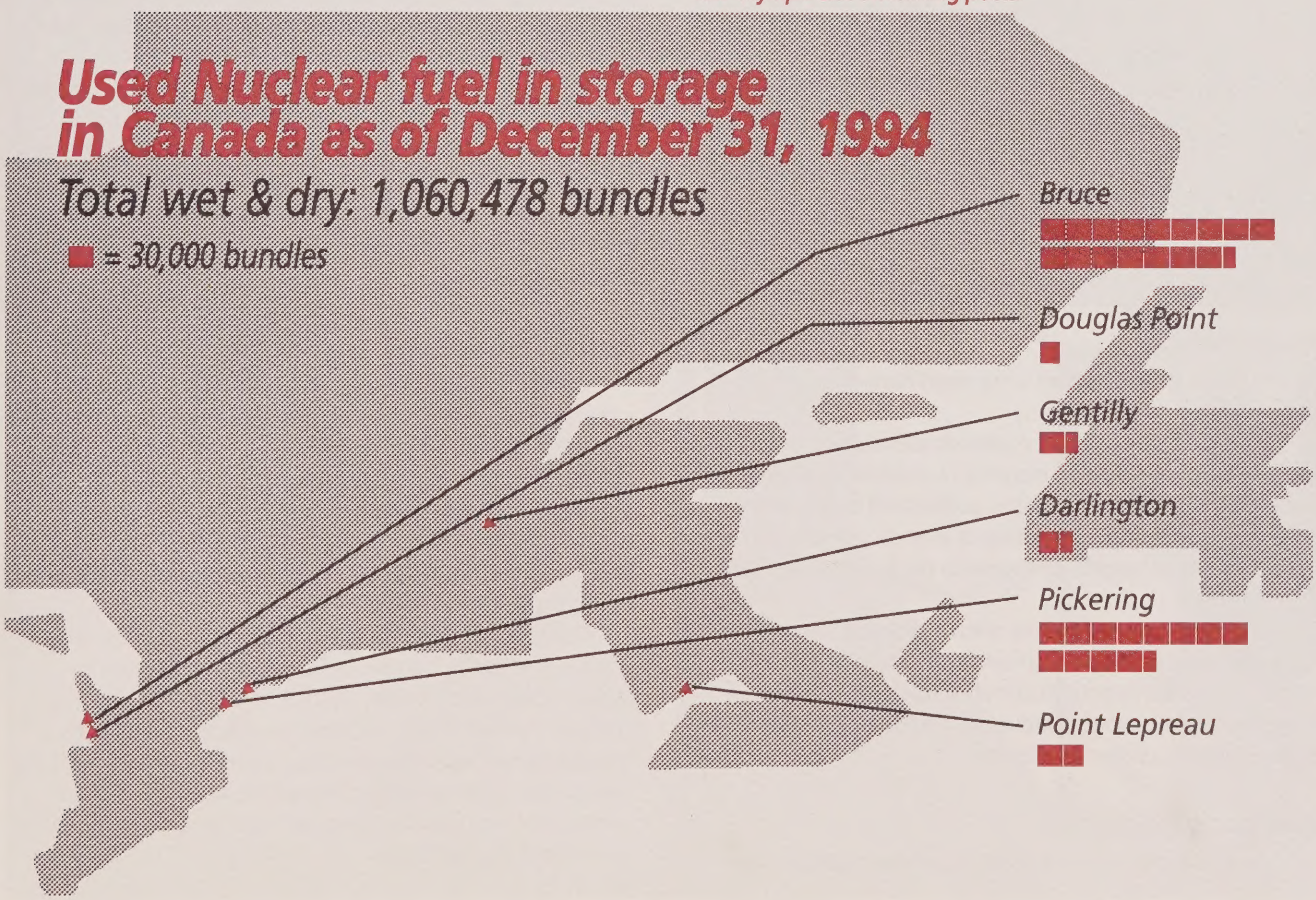
One aspect of used fuel that is potentially significant for disposal is that most of its original energy content remains untapped. Only a tiny fraction is used during its time inside a reactor. In a complex procedure, the waste products that spoil the uranium dioxide's use as a fuel can be removed. The remaining material can then be mixed with fresh uranium and recycled into new fuel bundles.

Today, this reprocessing technique is uneconomical for Canadian utilities, who can buy relatively inexpensive and secure supplies of fresh uranium. It is only significant because it is technically possible and because no one can predict with certainty the economic conditions and energy requirements that may prevail in the future.

Reprocessing today offers some advantages for countries such as France, the United Kingdom, Japan and others, who have no local uranium resources and employ a reactor design that uses fuel of a different type.

The Canadian concept for deep geologic disposal of nuclear fuel waste does not provide for recovery of the used fuel after a repository has been closed. Based on current-day economics, this would effectively eliminate the option for reprocessing.

***In storage:** Ontario's 20 power reactors produce most of Canada's nuclear fuel waste. Quebec and New Brunswick each have one CANDU station and produce proportionally less. All of the nuclear fuel waste created in Canada to date would fit into a few Olympic-size swimming pools.*



The AECB
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The hazards of nuclear fuel waste

Summary

- Nuclear fuel waste emits high levels of radiation that can destroy living cells or seriously disrupt their normal functions.
- Elements in the waste emit two types of radiation: penetrating rays (similar to X-rays), and particles that have little penetrating power. Both types are hazardous.
- Penetrating radiation can pass through living tissue, destroying or damaging cells. The waste must be shielded to protect humans from this type of radiation.
- Particle radiation is hazardous only if the substances that emit it are inhaled or swallowed. Since some of the contaminants in used fuel emit this type of radiation for millions of years, any waste disposal concept must limit the release of these contaminants into the general environment.

Warning: *The trefoil is the international warning symbol for radiation.*

Introduction

Used nuclear fuel is the most hazardous type of radioactive waste in Canada.

To appreciate why most countries with nuclear power programs are investigating disposal of used fuel in deep underground repositories, and to understand the reasoning behind similar thinking in Canada, it is necessary to consider the nature of the hazards contained in the fuel after it is taken from a reactor.

Used fuel is so radioactive when it emerges from a reactor, workers must handle and transfer it to nearby water-filled storage bays with remotely controlled equipment. At this stage it emits two types of radiation: penetrating and particle. Both represent a potential hazard.

Penetrating radiation

Penetrating radiation, known as gamma radiation, can easily pass through human tissue to damage cells or disrupt their functions. Depending on the dose received, the effects of gamma radiation on humans range from death within a few hours, to a slight increase in the risk of developing fatal cancers later in life. Substances emitting this type of radiation must be surrounded by a shield of water, lead, concrete, rock or other substance to protect anyone in the immediate area from harm.

The high level of gamma radiation in nuclear fuel waste decreases to very low levels after about 500 years. At that time, a person could remain in the same room with the waste for extended periods of time with no significant risk. Indeed, nuclear fuel waste becomes 100 times less radioactive after even a year in water storage, and 1,000 times less radioactive after five years.

Particle radiation

On the other hand, particle radiation (alpha and beta radiation), emitted by some of the long-lived radioactive substances in the waste (Iodine-129, Cesium-135, Technetium-99 and Plutonium-239), presents a potential hazard for hundreds of thousands of years. Neither alpha nor beta particles can penetrate deeply into the body, but they can affect cell function and cause cancer if substances emitting radiation of this type are ingested or inhaled.

Particle radiation is of most concern to scientists and engineers studying nuclear fuel waste disposal. The substances that emit this type of radiation are locked into the grains in the fuel. They could only harm humans in the far future if groundwater dissolved the grains and transported the substances to the surface and these substances were then swallowed or inhaled. Any disposal plan must be designed to minimize this possibility.

Release pathways

Many specialists are confident that deep geological burial of used nuclear fuel can successfully isolate the waste from the environment for the 500-year period required for the penetrating radiation to decline to a safe level. On the other hand, no one can state with certainty that this isolation will continue over the thousands of years needed for particle radiation to decay to equally safe levels.

It is the Control Board's responsibility, therefore, to consider all possible means by which this radioactivity might escape, even after very long periods of time. It must be certain that any disposal concept includes measures to reduce the risks to human health and the environment to acceptable levels.

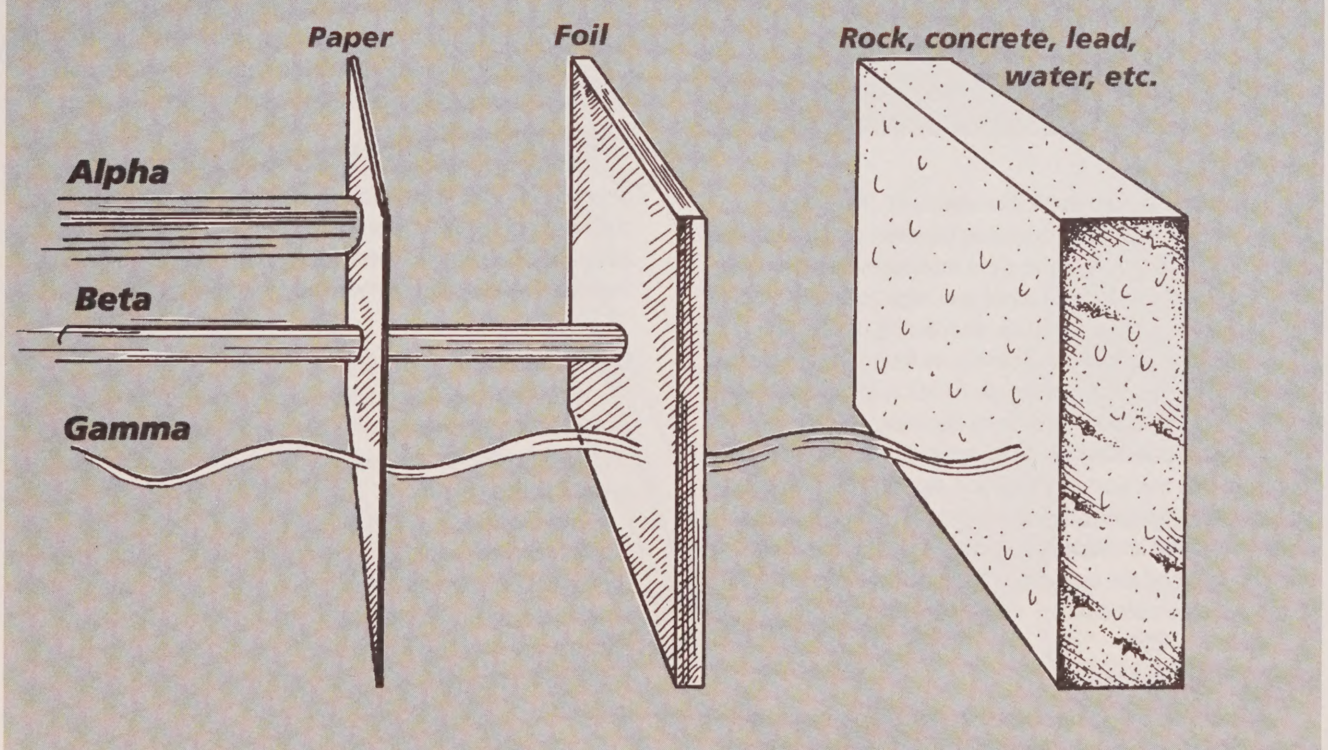
The Canadian disposal concept is to bury the waste deep in rock formations. The movement of deep groundwater is the only way radioactive substances in the waste could reach the surface, and the disposal system must minimize this possibility.

Further, the concept must take into account, and minimize, the possibility of human intrusion. The waste must be buried deep enough to deter intrusion. The repository should also be located in an area with limited deposits of valuable minerals or other substances that might attract the attention of future generations.

Radiation: *Particle radiation, which consists of alpha and beta particles, cannot penetrate beyond the outer layers of human skin. It holds little danger for humans or animals unless they inhale or swallow substances emitting it. Once inside the body, however, it can damage cells. This type of radiation persists for hundreds of thousands of years. Nuclear fuel waste contains elements that emit this type of radiation, and thus the release of these contaminants into the environment must be limited to levels that are safe.*

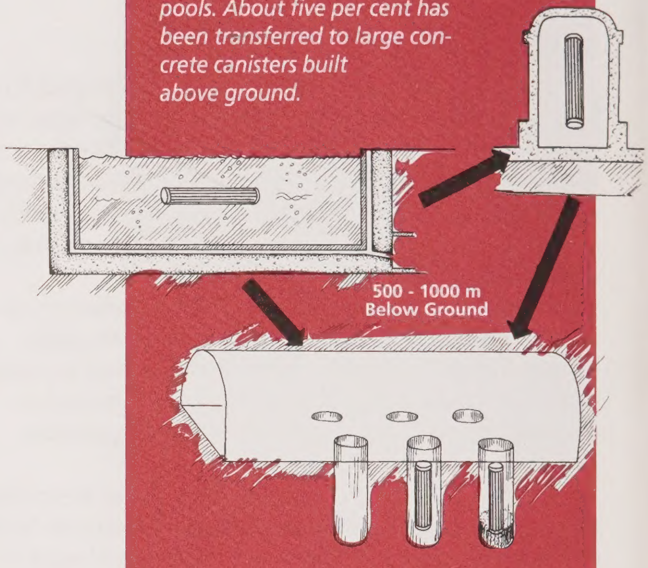
Nuclear fuel waste also emits gamma radiation, which can penetrate the body and destroy cells or interfere with their operation. Substances emitting this type of radiation must be surrounded by a thick shield of rock, concrete, lead or water. Gamma radiation in nuclear fuel waste declines to very low levels after about 500 years.

Penetrating power of radiation



Managing nuclear fuel waste

Storage vs disposal: *Canadian utilities now store their nuclear fuel waste at reactor sites under Control Board supervision. Most of this material lies in specially constructed water-filled pools. About five per cent has been transferred to large concrete canisters built above ground.*



Summary

- The Atomic Energy Control Board distinguishes between *storing* and *disposing of* nuclear wastes. Storage requires human intervention for maintenance and security and allows recovery of the waste; disposal does not.
- The Control Board's main goal in regulating waste management — storage or disposal — is to ensure that waste never creates unacceptable risks to human health or the environment.
- While many radioactive wastes require a relatively short amount of time in a storage facility while they decay, the radioactivity in used nuclear fuel is hazardous for thousands of years.
- The Canadian concept currently being studied includes a multi-barrier system to isolate and contain the waste deep within stable rock formations in the Canadian Shield over the time it needs to decay.

Introduction

In regulating nuclear waste management, the Atomic Energy Control Board distinguishes between *storage* and *disposal*. Storage is a relatively short-term management technique that permits retrieval of the waste and requires some element of intervention — maintenance, monitoring or security.

Disposal is permanent. There is no intent to retrieve the waste, and no need for human intervention to maintain safety and security while the radioactivity declines.

In both cases, however, the Control Board's main goal is to ensure that the waste will not add significantly to the natural radiation present in the environment. Before it issues licences to build and operate any waste facility, the Board must be satisfied the radioactivity will be contained and not create unacceptable risks — now, or in future.

Used fuel in storage

All nuclear fuel waste spends its first five or six years in water-filled storage bays. The water cools the fuel and blocks its radiation. It can then either remain in water storage or be transferred to above-ground concrete canisters. Canister storage is relatively new in Canada. At the end of 1994, only about 5% of all nuclear fuel waste was stored this way.

While used fuel could be stored in water or in concrete canisters for decades, its long-lived radiation hazard has prompted governments and utilities to seek a socially acceptable way to dispose of it safely, without the need for future human supervision or intervention of any kind.

A range of solutions for disposal has been suggested — depositing the waste on or under the seabed, in deep boreholes, in abandoned mines, in glacial ice sheets and in space. Canadian specialists agree with the current international consensus, however, that used fuel should be buried in deep underground chambers.

The type of geological media under consideration depends on what is available in each country. Germany is studying salt deposits, the United States is focusing on volcanic rock, Belgium is investigating clay, and Canada, like Sweden, Finland, and Switzerland, is studying granite.

Canadian disposal concept

In 1978, the governments of Canada and Ontario announced a program to evaluate the geologic disposal concept and to develop the technology and processes to implement it in this country.

Atomic Energy of Canada Limited (AECL), Canada's nuclear research and development organization, was assigned the task of assessing the concept and developing and demonstrating the technologies needed to implement it. Ontario Hydro was asked to develop and demonstrate various technologies for storing (on an interim basis) and transporting used fuel.

The deep geologic disposal concept involves depositing used fuel in a vault 500 to 1,000 metres below the surface of the Canadian Shield in stable rock formations.

Nuclear fuel waste, a solid ceramic material that dissolves extremely slowly in water, would be sealed inside corrosion-resistant containers and placed in the vault. Special buffer and backfill materials would surround the containers and fill the disposal rooms and shafts. Finally, entrances would be sealed against intrusion after the repository had been filled.

The first metre or two of rock would absorb most of the penetrating radiation from the waste, which would be isolated and contained physically by the series of natural and engineered barriers.

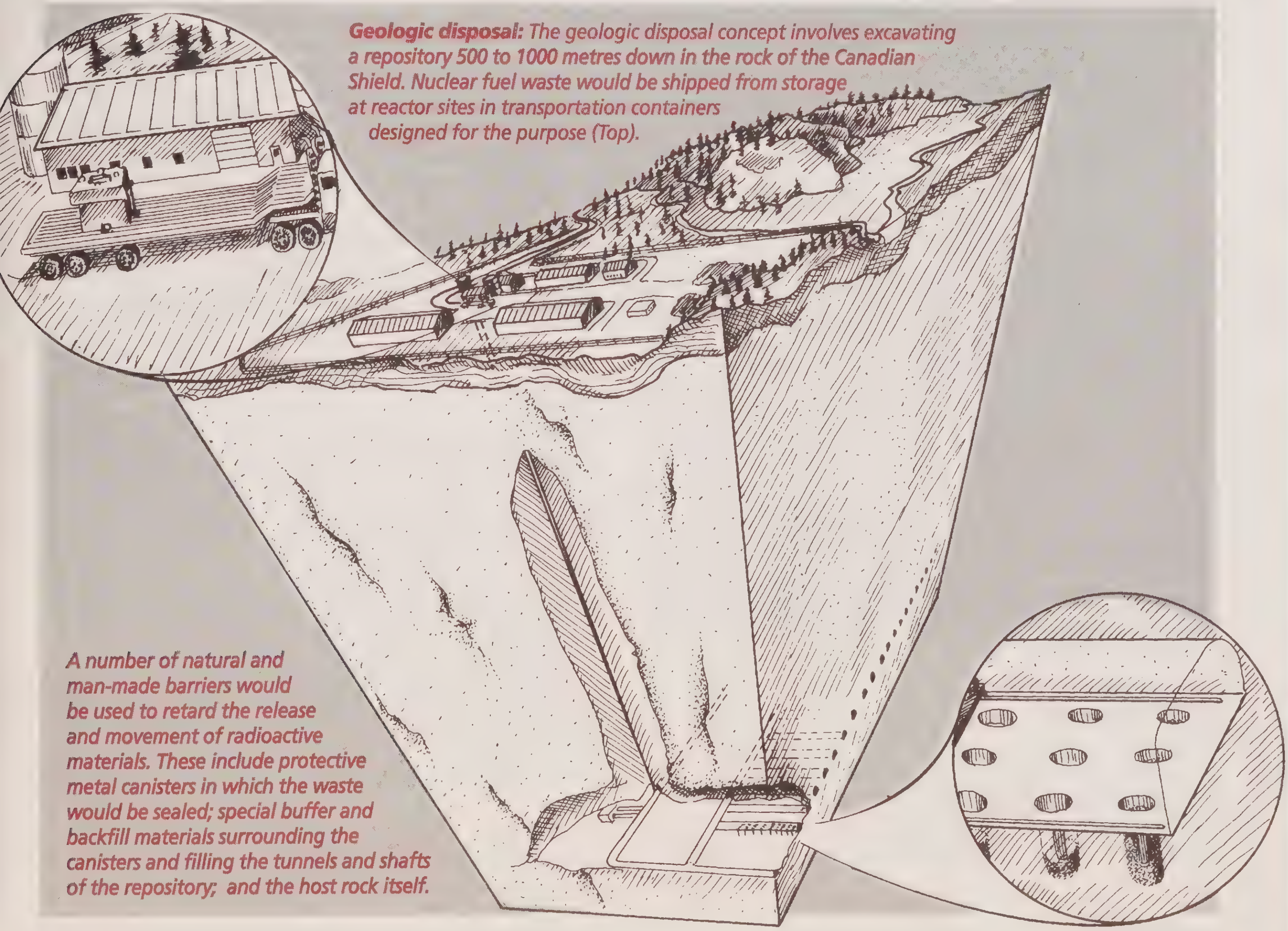
The concept assumes that water would eventually penetrate the waste containers, but not for several hundred years, when most of the radioactivity in the waste would have decreased to very low levels. Then, because the waste will not easily dissolve, only minute amounts would be expected to enter the groundwater.

The specially selected buffer materials packed around the containers would retain some of the radioactive substances dissolved in the groundwater. Bentonite, a type of clay, is one such material with the ability to absorb and retain dissolved radioactive substances. It could also serve as the active ingredient in special backfill material packed in the underground disposal rooms, access ways, and boreholes to further trap and retard the movement of radioactive substances.

The rock itself would be one of the principal barriers. The disposal vault would be located in stable rock with minimal cracks and low groundwater movement. Dead-end crevices and some minerals within the fractures or crevices would tend to trap dissolved radioactive substances.

If such a disposal facility became available, utilities could ship waste fuel bundles to the site after about 10 years in wet storage, or a combination of wet and dry storage. The facility would hold all the fuel waste created in Canada from the inception of the nuclear power program to well into the next century.

Once full, the repository would be sealed and closed, and the surface area could eventually be returned to its natural state.



Geologic disposal: *The geologic disposal concept involves excavating a repository 500 to 1000 metres down in the rock of the Canadian Shield. Nuclear fuel waste would be shipped from storage at reactor sites in transportation containers designed for the purpose (Top).*

A number of natural and man-made barriers would be used to retard the release and movement of radioactive materials. These include protective metal canisters in which the waste would be sealed; special buffer and backfill materials surrounding the canisters and filling the tunnels and shafts of the repository; and the host rock itself.

Concept assessment: the critical step

Summary

- An independent Environmental Assessment Panel (EAP) appointed by the government will lead the concept assessment process.
- The Environmental Assessment Panel created a Scientific Review Group (SRG) of 15 independent scientists to help it understand the complex technical aspects of geologic disposal.
- The Panel has also invited the public to take part in its formal hearings on the concept, which are expected to begin in late 1995 or early 1996.
- After completing its review, the Panel will present its recommendations to the government.
- The Atomic Energy Control Board, which is reviewing the disposal concept from its position as a regulator, is participating in the Panel's public review process.
- The Control Board's review will focus on technical issues related to health and safety, security and the protection of the environment.

***Panel:** The federal government set up an Environmental Assessment Panel in 1989 to review the safety, environmental and socio-economic implications of the Canadian concept of nuclear fuel waste disposal. The Panel will consider the scientific and technical assessment provided by an independent Scientific Review Group, and the comments and concerns expressed by other interested Canadians at a series of public hearings.*

Introduction

In 1977, the federal government asked Professor Kenneth Hare, Director of the Institute of Environmental Studies, University of Toronto, for views on nuclear fuel waste disposal. After studying a variety of options, Hare and his commission recommended Canada direct its research toward burying the waste deep in the stable rock formations of the Canadian Shield.

The government followed Hare's advice the next year, launching the Nuclear Fuel Waste Management Program (NFWMP) with the Province of Ontario. Atomic Energy of Canada Limited would study ways to immobilize and dispose of wastes, and Ontario Hydro would provide research on interim storage methods and the transportation of nuclear fuel waste.

As research proceeded, the two governments announced in 1981 that under a process they called Concept Assessment, they would not select a site for a disposal facility until research and development work on the concept had undergone a public review and had been accepted by both governments.

The government process for reviewing the concept

In 1988, the government directed the Federal Environmental Assessment Review Office (FEARO) to carry out the Environmental Assessment Review Process (EARP) on the waste disposal concept.

FEARO appointed an independent Environmental Assessment Panel (EAP) to lead the concept assessment process. The seven members of the Panel, drawn from various disciplines, including science, engineering, social science and environmental consulting, will review various approaches to disposal of nuclear fuel waste, including the options other countries are selecting.

In carrying out its review, the Panel will study a number of other factors, including:

- How nuclear fuel waste is currently stored at nuclear generating plants, and the transition from storage to disposal.
- The acceptability of AECL's research and development work on the disposal concept.
- Atomic Energy Control Board criteria by which the safety and acceptability of the disposal concept should be evaluated.
- Social, economic and environmental implications of a possible nuclear fuel waste disposal facility.
- The degree to which future generations should be relieved of the burden of looking after the waste.

Canadian specialists agree with the current international consensus that the most appropriate method of disposal of used fuel is burial in deep underground chambers.

To encourage Canadians to contribute to the review process, the Environmental Assessment Panel held open houses in 1990 so the public could ask questions about the disposal concept and the review process itself. It followed the open houses with public meetings in Ontario, Quebec, New Brunswick, Saskatchewan and Manitoba to help the Panel develop guidelines for AECL to follow in preparing an *Environmental Impact Statement* (EIS) on its waste disposal concept. The EIS is an overview of AECL's case for the disposal concept. It is the document on which the safety and viability of the concept will be judged.

The public has also been invited to take part in the Panel's formal hearings on the concept, which are expected to begin in late 1995 or early 1996.

Shortly after it was appointed, the Environmental Assessment Panel created a Scientific Review Group (SRG), 15 independent scientists with relevant backgrounds, to help it understand the complex technical aspects of geologic disposal. The SRG is critically reviewing the disposal concept and the related research from a scientific and engineering point of view.

The Panel will present its recommendations to the government after completing its review, which will include comments from not only its Scientific Review Group, the Control Board and the public, but other federal and provincial government bodies as well.

The Control Board's role in concept assessment

In regulating nuclear facilities, the Atomic Energy Control Board normally reviews a proposal for a facility when a prospective licensee seeks a site approval. Because of the unique nature of the Nuclear Fuel Waste Management Program, however, the Control Board is reviewing a generic concept before the site selection phase. Its role during the government's public review process is to:

- Identify the regulatory requirements and expectations before licensing an actual disposal facility.
- Provide the results of the Control Board's technical review of the concept for consideration by the Environmental Assessment Panel.
- Present the regulatory perspective on the broader issues being addressed by the Panel concerning nuclear fuel waste disposal.
- Illustrate how the Control Board would review a licence application for an actual disposal facility.

The Control Board will review the Environmental Impact Statement and provide a detailed technical evaluation to the Panel. This review will focus on technical issues related to health and safety, security and the protection of the environment.

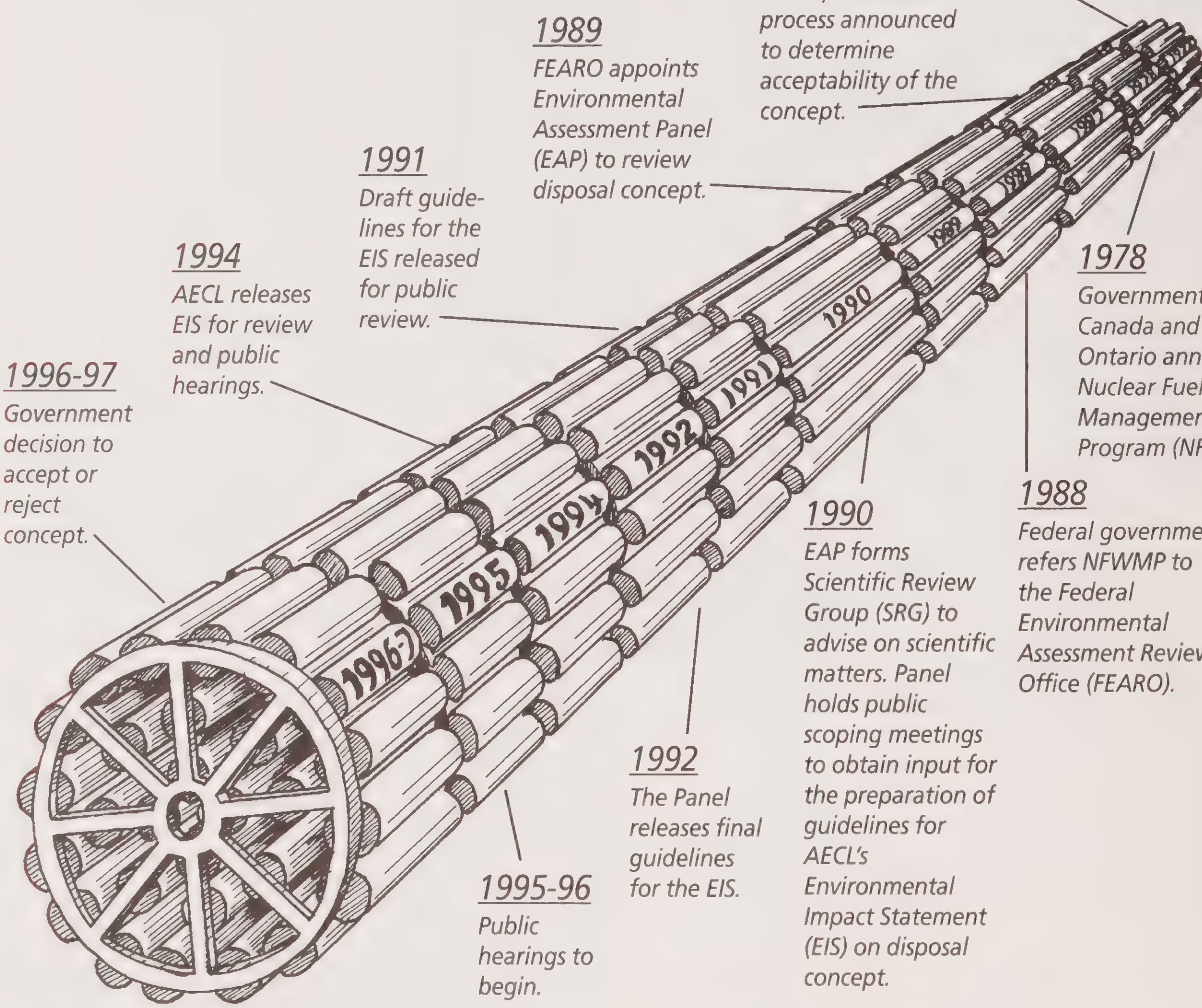
Further, the Control Board will treat the EIS as if it were a licensing submission to illustrate its regulatory review methods and positions on safety issues that would be important for the licensing of an actual repository.

Since the EIS represents only a generic feasibility and safety study of the disposal concept, it must demonstrate only that there is reasonable confidence that safety criteria can be met, and that the siting, design, construction, operation and closure of an actual repository are technically feasible. This means that detailed design and engineering studies are not needed. These would depend on the specific conditions at a site selected for future consideration.

Following the hearings, the Panel will submit its report and recommendations on the future direction of the national program to the federal government. Governments will subsequently have to choose a course of action.

Milestones

The roots of the Canadian Nuclear Fuel Waste Management Program began in 1977. A government decision on a future course of action is expected in 1996 or 1997.



1977
Hare Commission recommends Canada focus research on deep geologic disposal concept for nuclear fuel waste.

1978
Governments of Canada and Ontario announce Nuclear Fuel Waste Management Program (NFWMP).

1981
Concept assessment process announced to determine acceptability of the concept.

1988
Federal government refers NFWMP to the Federal Environmental Assessment Review Office (FEARO).

1989
FEARO appoints Environmental Assessment Panel (EAP) to review disposal concept.

1990
EAP forms Scientific Review Group (SRG) to advise on scientific matters. Panel holds public scoping meetings to obtain input for the preparation of guidelines for AECL's Environmental Impact Statement (EIS) on disposal concept.

1991
Draft guidelines for the EIS released for public review.

1992
The Panel releases final guidelines for the EIS.

1994
AECL releases EIS for review and public hearings.

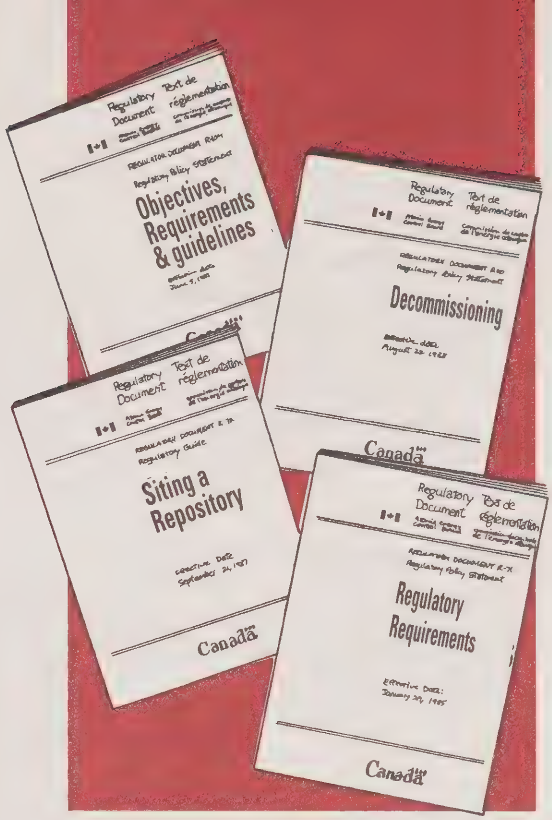
1995-96
Public hearings to begin.

1996-97
Government decision to accept or reject concept.

Assessing long-term safety

Summary

- The Atomic Energy Control Board will assess nuclear fuel waste disposal plans, such as the one developed by AECL, against a set of criteria and requirements it has developed on the critical safety issues associated with disposal.
- Four regulatory documents, which the Control Board issued between 1982 and 1986, detail these criteria and requirements.
- These documents focus on three basic safety objectives of any waste disposal facility: 1) Protect human health; 2) Protect the environment; and 3) Minimize the burden on future generations.
- When it has completed its assessment, the Control Board will report its findings to the federal Environmental Assessment Panel, which is reviewing the safety and environmental impacts of the concept.
- If the government decides to implement the concept, the Control Board will license all phases of the project: site selection, design and construction, operation, decommissioning and closure, and site abandonment.



Disposal criteria: *The Control Board has developed extensive criteria and requirements for nuclear fuel waste disposal. These are outlined in four regulatory documents that are available to anyone who requests them.*

Introduction

Between 1982 and 1986, the Control Board issued four regulatory documents that state its criteria and requirements for addressing the critical safety issues associated with nuclear fuel waste disposal.

In developing these documents, the Control Board drew on its own expertise as a nuclear regulator, and on similar work being conducted by worldwide organizations such as the International Commission on Radiological Protection, the United Nation's International Atomic Energy Agency and World Health Organization, and the Nuclear Energy Agency of the Organization for Economic Co-operation and Development.

Objectives of waste disposal

Regulatory Document 104, *Regulatory Objectives, Requirements and Guidelines for the Disposal of Radioactive Wastes — Long-Term Aspects*, deals with the regulatory basis for judging the long-term acceptability of radioactive waste disposal options.

The document focuses on the following three major objectives of nuclear waste disposal and the means to achieve them:

- Protect human health.
- Minimize the burden on future generations.
- Protect the environment.

Protecting human health

The Control Board has ruled that no waste disposal facility, even if left unmarked and unguarded in the future, should subject an individual to a predicted radiological risk greater than a one-in-a-million chance of fatal cancer and serious genetic effects in a year. That risk is much smaller than the one from the radiation dose every human being receives from nature.

Minimizing the burden on future generations

Radiological risk must be calculated without depending upon long-term institutional controls, such as monitoring the disposal site after closure, keeping records, and restricting land-use through registration in property deeds or by means of municipal bylaws or other legal instruments. Over long periods of time, such controls may change, be interrupted or disintegrate altogether.

Further, contemporary ethics suggest that, where possible, the generation of Canadians who create specific waste materials should dispose of them.

Finally, there should be no predicted risks to human health in the future that would not be currently accepted.

The document focuses on the following three major objectives of nuclear waste disposal and the means to achieve them:

- *Protect human health.*
- *Minimize the burden on future generations.*
- *Protect the environment.*

Protecting the environment

The Control Board requires that radioactive waste disposal facilities not have any predicted future impacts on the environment that would be unacceptable today, from either radioactive or non-radioactive contaminants in the waste. Further, these facilities should only be located in areas where there is little known natural resource potential.

General criteria for nuclear fuel waste disposal

Regulatory Document 71, *Deep Geological Disposal of Nuclear Fuel Waste: Background Information and Regulatory Requirements Regarding the Concept Assessment Phase*, outlines the general criteria for a disposal facility. It states that the concept for disposal of nuclear fuel waste in a deep geological repository must take nine requirements into account:

1. A facility must be safe without relying on future generations in any way.

2. A disposal system must be based upon multiple barriers that incorporate both man-made and natural components.

3. All components and systems must be subject to a quality assurance program at all stages up to, and including, closure.

4. A disposal system must be able to accommodate natural disturbances that are likely to occur without any significant risk to members of the public.

5. The effectiveness of the disposal system must not be compromised by any provision made for retrieving the waste (should provision be made for it) or by conducting any measurements in and around the facility either before or after it has been closed.

6. Before closure, the concept must, as a contingency measure, incorporate methods for waste retrieval.

7. The chosen concept must be technically feasible using available technology, or technology that can be developed with a reasonable degree of certainty.

8. The socio-economic impacts resulting from a deep geological disposal facility must be addressed.

9. During operations, the repository would be required to meet current regulations regarding radiological health and safety; conventional health and safety; environmental protection; safeguards and security; and transportation of radioactive material.

Siting

Because a disposal facility depends upon a combination of man-made and natural (geologic) barriers to successfully immobilize and contain the waste over very long periods of time, the correct siting of a facility is critical.

In its regulatory document on siting, R-72, *Geological Considerations in Siting a Repository for Underground Disposal of High-Level Radioactive Waste*, the Control Board outlines the geological criteria that will contribute to successfully locating an underground repository to ensure long-term safety. For example, a rock mass with low water flow and favourable chemical conditions, located in a geologically stable region, will retard the release and movement of radioactive material.

The Control Board points out that it is not necessary to identify a site that can be considered best in all respects. Rather, it would be sufficient to identify a site where all decision criteria are met satisfactorily, and where geological and

biosphere conditions are such that a convincing demonstration of a high standard of safety and radiological protection can be achieved.

R-90, *Policy on the Decommissioning of Nuclear Facilities*, deals with the process of safely closing a nuclear facility or area and decontaminating it, ideally so the location may be used for other purposes.

How a disposal concept might be implemented

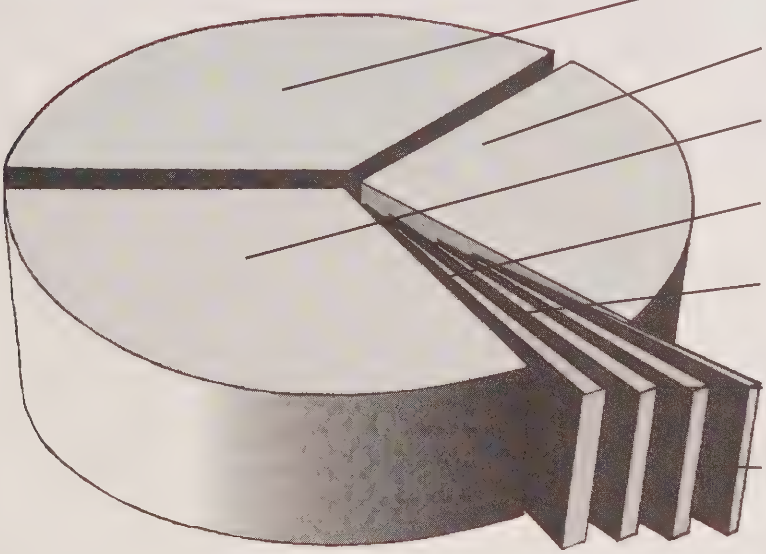
The government has not yet approved any nuclear fuel waste disposal system for use: many more steps will be required before a repository is constructed. The government will likely base any decision to proceed on the Panel's recommendations at the conclusion of the concept assessment process. Should it decide to proceed, each major stage of the implementation will require the approval of the Atomic Energy Control Board.

Site selection

A potential site would need to possess suitable social and technical characteristics, such as being supported by the local communities. The process for finding such a site has not been determined, but would likely involve discussions between all the involved parties at an early stage. Once a site, or sites, are identified, a proponent would need Control Board licensing approval before beginning any detailed investigations or major preliminary work on site.

A site licence would permit the applicant to conduct studies to determine the site's characteristics and suitability for a disposal facility. The licence could also incorporate various conditions established during the site selection process, as well as any terms and conditions the Control Board considers necessary in the interest of health and safety, security and the protection of the environment.

Average radiation doses



** This is the Control Board's regulatory criteria for the average annual dose received by an individual living at the discharge point from a nuclear fuel waste disposal vault in the future. This dose is a small fraction of the average annual exposure received from natural and man-made sources of ionizing radiation as presented in the pie chart.*

Design and construction

While working at the site, the licensee would begin design studies to form the basis of an application for a construction licence. The application would need to include the design of the facility, a detailed site description and a preliminary long-term safety analysis. The Control Board would base its decision to issue a construction licence on this application.

The licence would authorize construction of the basic structures above and below ground level and would again include any conditions the Control Board deemed necessary. Inspections by Board staff would ensure that the licensee met all standards and licence conditions.

During construction, the licensee would develop the final design and operating procedures for the repository. Before allowing operations to begin, the Control Board might also ask the licensee to:

- Demonstrate some of the technology.
- Verify aspects of design and construction.
- Confirm operational safety predictions.
- Optimize operational procedures.

Information obtained during the construction phase would be used as the basis for a safety assessment report. This report, in turn, would form part of the application for an operating licence.

The government has not yet approved any nuclear fuel waste disposal system for use; many more steps will be required before a repository is constructed.

Operation

Operation would begin with the first routine emplacement of nuclear fuel waste in the repository, and would have to be in accord with the terms and conditions of the operating licence. The licence would also ensure that the operator followed all plans for controlling and monitoring any environmental discharges, for taking remedial action if necessary, and for controlling any possible exposures of workers and the public to radiation.

Decommissioning and closure

Once the repository was filled, licensing approval would be needed to close and seal it, and to decommission and dismantle the surface facilities. The repository would not be allowed to close, however, until the licensee could show that no further controls were necessary to maintain safety.

The repository would likely be monitored for a time after it had been filled to confirm that all systems were performing properly and would continue to do so.

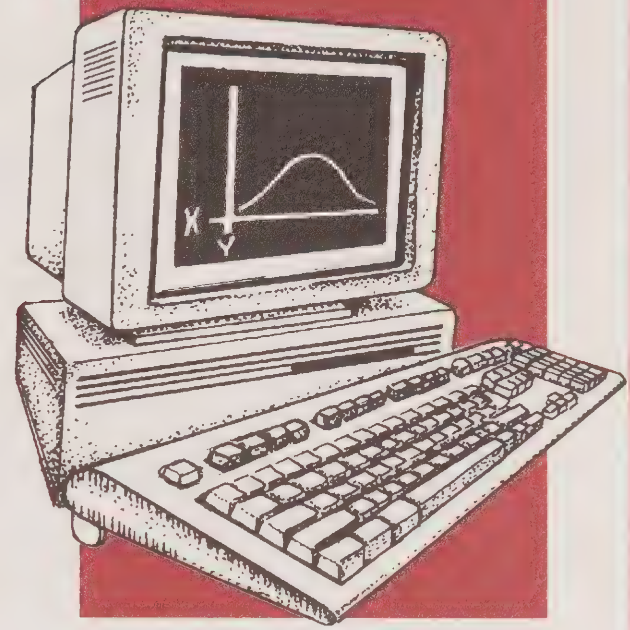
After the repository is closed and sealed, and the surface facilities decommissioned, no further monitoring would be required. Monitoring might continue, however, to confirm that no contaminants were being released. Such post-closure monitoring could not interfere with the integrity or effectiveness of the repository itself.

Site abandonment

After the facility is decommissioned and closed, the licensee could receive permission to abandon the site. After abandonment, the government might preserve the identity and location of the facility and control land use in the area. It might also continue some level of site monitoring to check for any environmental impacts and ensure there have been no human disturbances or intrusions at the site.

Ensuring compliance

***Confidence:** Computer modeling is one tool that can be used to generate confidence in a disposal concept.*



Summary

- The Atomic Energy Control Board must determine how well the disposal concept complies with long-term safety criteria and requirements.
- While there are techniques available for demonstrating this compliance, making it possible to take appropriate regulatory decisions, no one can guarantee absolute safety, particularly over the long time frames needed for nuclear fuel waste disposal.
- The concept documentation should show a variety of approaches to demonstrating safety, including simple and direct approaches that non-technical audiences can easily understand.
- The use of natural analogues to demonstrate that containment and isolation has occurred in nature over very long periods of time will be particularly useful in building confidence in the long-term safety aspects of the disposal concept.

Introduction

In reviewing the concept for a nuclear fuel waste disposal system, the Atomic Energy Control Board must determine how well the generic facility complies with long-term safety criteria and requirements. These criteria and requirements are flexible enough to allow a proponent to consider a range of technical possibilities for meeting them.

For example, the Control Board sets specific limits for protecting human health without specifying how to meet them. That permits a proponent to evaluate various means of satisfying the criteria and to incorporate those it feels are most appropriate in the context of its overall proposal. The Control Board must then evaluate the proposal to determine whether it is acceptable.

Can such a determination be undertaken with a high degree of confidence?

This question was addressed in 1991, following extensive work at the international level. The International Atomic Energy Agency (IAEA) and the Nuclear Energy Agency (NEA) have published an *International Collective Opinion* concerning the evaluation of the long-term safety of radioactive waste disposal. This document concluded that:

"*Appropriate use of safety assessment methods, coupled with sufficient information from proposed disposal sites, can provide the technical basis to decide whether specific disposal systems would offer to society a satisfactory level of safety for both current and future generations.*"

While the collective opinion states that the analytical tools are available to determine safety, it should be noted that no one can guarantee absolute safety, particularly over the long time frames associated with nuclear fuel waste disposal.

What the Control Board will look for in the disposal concept

In summary, the Control Board expects a documented feasibility and safety study of the geologic disposal concept. In the case of the current AECL proposal, the Environmental Impact Statement (EIS) serves as the documentation. In reviewing the work, the Control Board will use internationally accepted safety assessment methods to help it decide whether the concept will meet its requirements. These methods include analytical tools, such as computer codes and models, and detailed studies of natural analogues.

At the concept stage of the program, the demonstration of safety does not need to be as conclusive as would be required for an application to construct and operate an actual repository. The work detailed in the EIS should, however, demonstrate that safety criteria can be met, and that repository siting, design, construction, operation and closure are technically feasible using either available technology, or technology that can be developed without undue difficulty.

The documentation should verify that a number of suitable sites for a repository exist and can be identified and characterized. It should also include a description of the natural

and engineered barriers that will isolate and contain the waste deep in geologic formations.

Further, the documentation should show that a variety of independent assessment methods, based both on observations of natural systems and on the results of analytical studies and calculations, were used to substantiate conclusions. It should also provide evidence that a conservative approach was used in the analyses and design to widen the safety margin.

A variety of approaches

The Control Board will expect the EIS document to describe a variety of approaches that demonstrate safety. System components, such as the waste containers, that have been conservatively designed or even over-designed, for example, could demonstrate safety and compliance with criteria and requirements. This may reduce the need for complex safety assessments and allow the use of simple techniques that non-technical individuals can more easily understand.

Safety should also be shown in a variety of independent ways. For example, evidence that radionuclides will move slowly through the rock could be provided by analysing groundwater and determining its age, by conducting field tests, by performing computer analyses to evaluate the potential for groundwater to transport contaminants, and by using natural analogues as examples.

The Control Board will expect the document to include simple and direct approaches to demonstrating safety. These include analyses that render geological, ecological and other systems simpler and more easily understood.

The use of natural analogues will also help the Control Board determine whether the concept will meet its criteria. Analogues can:

- Form the basis of reasoned arguments supporting the long-term performance of a repository.
- Combine events and processes over long time frames.
- Verify the reliability of other approaches to demonstrating safety, such as the use of computer models to evaluate the performance of a repository.

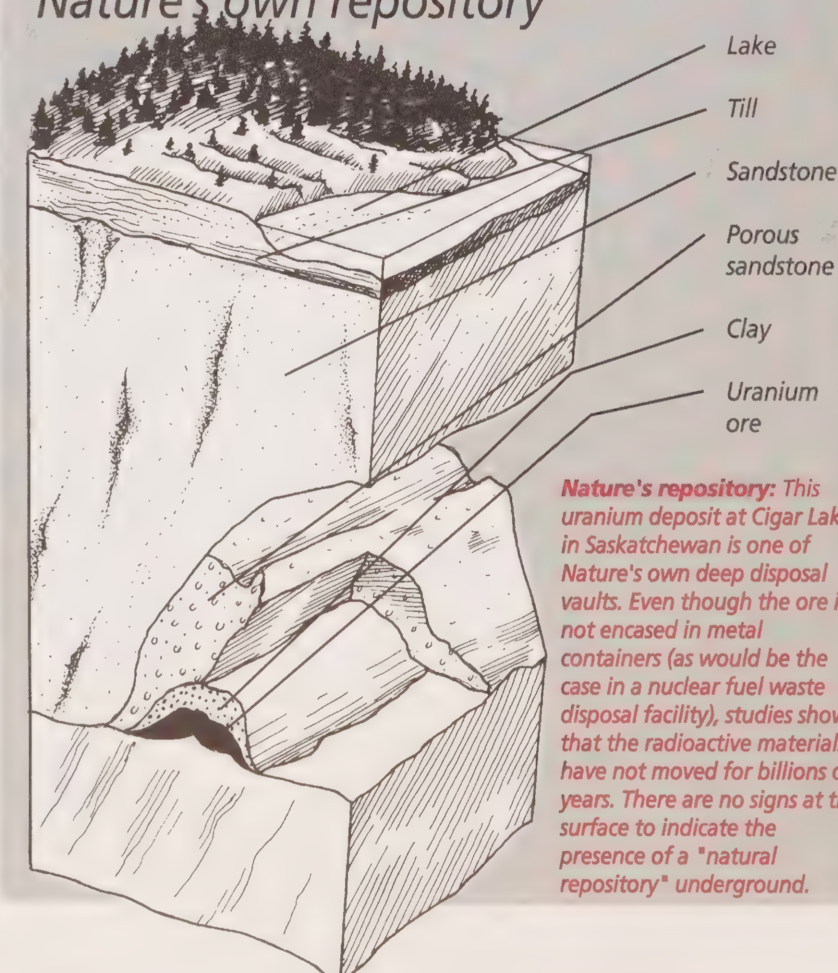
Natural analogues of the disposal system as a whole can demonstrate how geologic containment occurs in nature.

For example, studies of the uranium deposits at Cigar Lake in Saskatchewan show that its radioactive materials have been contained for hundreds of millions of years. Similarly, most of the plutonium and other long-lived radioactive products formed in natural reactors that operated two billion years ago in a uranium ore deposit at Oklo, in Gabon, West Africa, remained where they were produced.

Computer models provide a means of evaluating, understanding and documenting the complex relationships between the processes, events and features that affect a repository's performance. They provide a means for bringing together all the data and information for a process or site, and evaluating the consistency of the information.

No one can predict exactly how a repository will perform, however, because a large number of variables may affect operation over a very long period of time. Nevertheless, computer models can indicate general trends. They, along with the use of natural analogues, sound engineering judgment, and other factors, should form the basis of reasoned arguments in the documentation that provide confidence that the generic concept can meet safety criteria.

Cigar Lake,
Nature's own repository



***Nature's repository:** This uranium deposit at Cigar Lake in Saskatchewan is one of Nature's own deep disposal vaults. Even though the ore is not encased in metal containers (as would be the case in a nuclear fuel waste disposal facility), studies show that the radioactive materials have not moved for billions of years. There are no signs at the surface to indicate the presence of a "natural repository" underground.*

Siting a nuclear fuel waste disposal facility

Summary

- A disposal site for nuclear fuel wastes would be sought only after a disposal concept had been accepted by government.
- The federal government would likely set up a process to evaluate all possible sites and to recommend one or two of them for in-depth technical study.
- Since a disposal facility could create local employment opportunities and economic benefits, it is hoped that some communities would volunteer to "host" a facility. The siting process would need to consider such requests and ensure the site meets all geological and technical criteria.
- Before the proponent could undertake any detailed work at a proposed site, it would have to obtain approval from the Atomic Energy Control Board.

Introduction

Successfully siting waste management facilities, even for household garbage, is a major challenge. Attempts to establish waste disposal sites, regardless of the types of waste involved, have often yielded only anger, frustration, delay and failure on all sides.

In Port Hope, Ontario, for example, attempts to site a low-level radioactive waste management facility for by-products of a local uranium processing plant met with failure. In 1986, the federal government concluded that the selection process was faulty. A government task force recommended the process become a co-operative effort among all stakeholders.

A similar approach may be employed to establish a site for a nuclear fuel waste facility.

While any location under consideration would have to meet the technical criteria established for safe disposal, experience in trying to locate disposal facilities shows that additional factors would need to be taken into account. These include social, economic and political elements; public opinion; existing land value and use; cultural or historical interest and others. Stakeholders would be given an opportunity to

Siting a facility: *Establishing any type of waste disposal site is more successful when the people who live in candidate communities are fully informed about all aspects of such a project, and when they can have input in the process and decide for themselves whether they wish to host a facility.*

discuss and evaluate these factors — and the potential advantages and disadvantages of permitting a disposal facility to be built on a specific site.

Siting a national fuel waste repository

The government would begin the search for a site on which to locate a national nuclear fuel waste repository only if it approved the deep geologic disposal concept. It would base its decision on the report and recommendations of the Environmental Assessment Panel appointed to review the concept.

The Panel has been requested to recommend how to proceed should the concept be found acceptable. Although Atomic Energy of Canada Limited conducted the research program to assess the concept from the technical perspective and to develop the technologies needed to execute it, the Panel could suggest other organizations to build and operate an actual facility.

Regardless of who implements the concept, they would first need to obtain a site licence from the Atomic Energy Control Board before undertaking any significant work or detailed investigations at a site. Therefore, a preliminary selection process would be needed to limit the number of candidate sites being considered. Specific guidelines for this screening process would emerge from the review and recommendations of the Environmental Assessment Panel as well as from government deliberations.

Given the difficult and sensitive nature of siting a nuclear fuel waste disposal facility, the government would likely set up a special process to:

- Solicit volunteer sites/communities.
- Publicly review the sites offered for further study.

- Examine the suitability of each site based upon information obtained from preliminary activities.
- Recommend one or more sites for further investigation.

If a site were offered by a community for consideration, and it was subsequently recommended for detailed study, a program of site characterization would be developed for it and submitted to the Control Board to support the site licence application.

The licence would allow the applicant to conduct a detailed site investigation, while stipulating any conditions the Control Board considered necessary to protect health and safety, security and the environment.

Technical guidelines for siting

The Control Board may need to develop additional technical criteria and guidelines for the siting phase to complete its requirements for long-term safety and security. These technical guidelines would be based on:

- The preliminary guidelines prepared for the concept assessment phase of the Nuclear Fuel Waste Management Program.
- Internal Control Board studies.
- The recommendations of the Environmental Assessment Panel.
- Guidelines developed for other nuclear facilities.

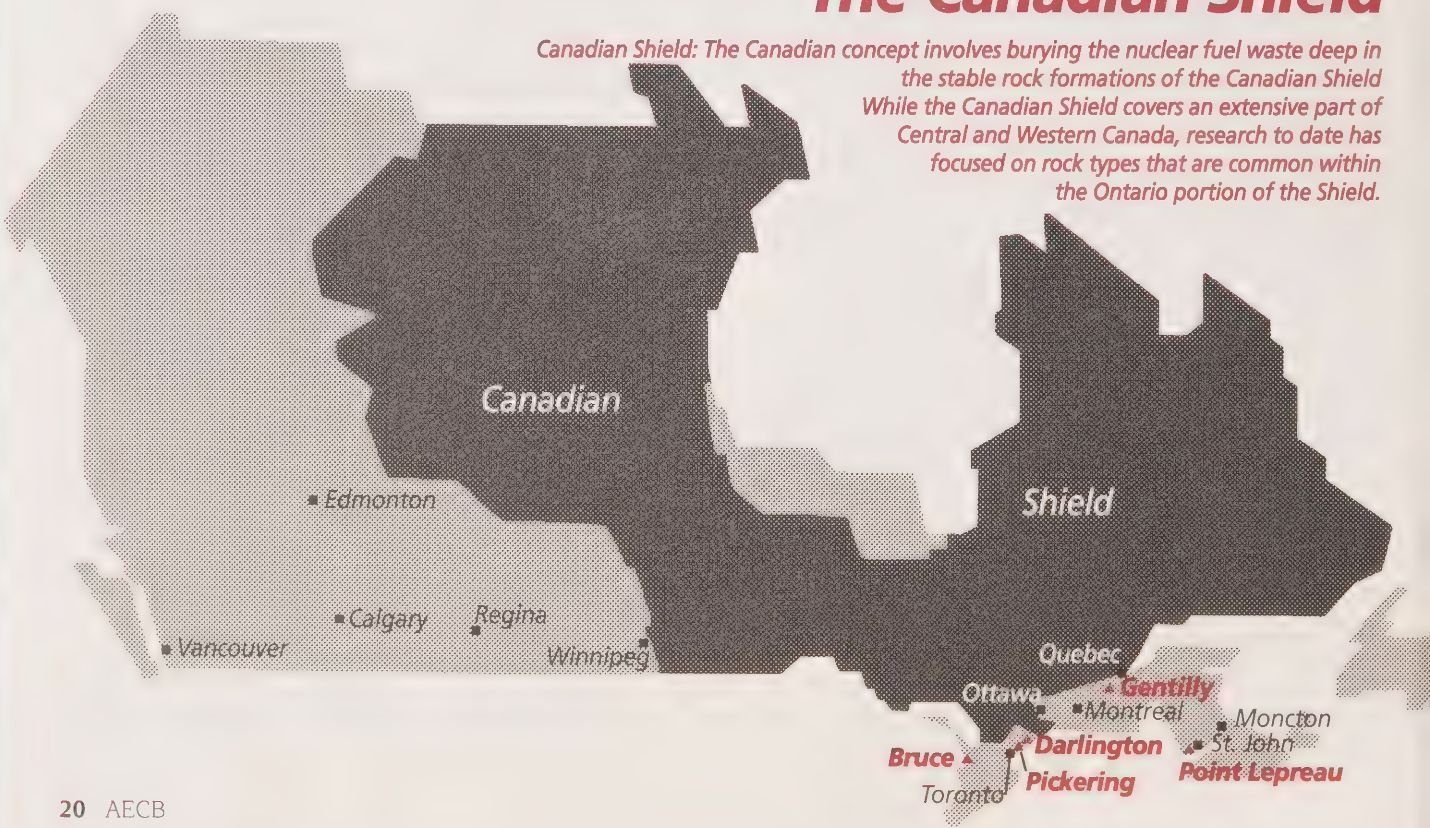
Up to now, the Control Board has identified the following five technical factors for long-term safety and security that must be satisfied during the siting phase:

1. The host rock and geological system should work together to retard the release and movement of radioactive materials.
2. There should be little likelihood the host rock will be exploited as a natural resource. A host rock that contains a commercially valuable commodity such as gold, oil, salt or potash, or a strategically important material, may become the target of future miners.
3. The site should be located in a region likely to remain geologically stable.
4. The host rock should be able to withstand natural stresses and those resulting from the repository itself without losing its capability to retard the release and movement of radioactive materials.
5. The host rock should be large enough so the vault can be built deep underground and well removed from human interference and erosion.

It is the Control Board's job to ensure that all of these technical factors are considered and the requirements for long-term safety, security and protection of the environment are satisfied during the site selection process.

The Canadian Shield

Canadian Shield: The Canadian concept involves burying the nuclear fuel waste deep in the stable rock formations of the Canadian Shield While the Canadian Shield covers an extensive part of Central and Western Canada, research to date has focused on rock types that are common within the Ontario portion of the Shield.



Packaging and transporting nuclear fuel waste

Summary

- If Canada establishes a national nuclear fuel waste disposal facility, nuclear fuel waste would be transported to the site under strict regulations that meet international safety standards.
- Because accidents sometimes occur during transport, the Control Board regulates the design of the package in which waste is shipped to ensure radioactivity is not released, even in the most severe type of accident.
- The actual transportation of nuclear fuel waste, in the approved packaging, would also be regulated under the hazardous goods regulations of other agencies, depending on the mode of transport.

__Transport:__ Whether it travels by truck, rail or ship, nuclear fuel waste will be transported in containers approved by the Control Board and which have demonstrated their ability to survive severe accidents without risk to humans or the environment.

Introduction

If a nuclear fuel waste repository is built, used nuclear fuel bundles would be shipped to a repository from storage facilities near the reactors they once powered. At the end of 1994, there were 1,060,478 such fuel bundles in storage at nuclear power stations in Ontario, Quebec and New Brunswick.

The Atomic Energy Control Board, together with federal and provincial agencies involved in regulating the transportation of hazardous goods, would ensure the protection of the public, transport workers and the environment from any radiological effects associated with these shipments.

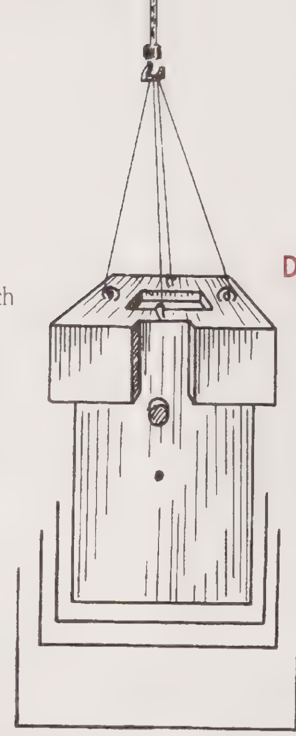
The task of shipping nuclear fuel waste safely may appear daunting, but the Canadian and international record over the past 30 years is good. While some shipments of radioactive material were involved in serious accidents, none was known to cause significant radiological injury.

The reason? Nuclear regulators worldwide assume that accidents can happen and rely on package design, rather than operational control, for safety.

The strategy is: *Ship radioactive materials only in packages that will contain their contents and protect against radiation, even in severe accidents involving heavy impact, submersion in water or exposure to high heat.*

This strategy underlies international regulations governing the packaging and shipment of radioactive materials, including nuclear fuel waste, which have evolved over three decades and are reviewed and amended regularly.

Within Canada, the Atomic Energy Control Board shares responsibility for regulating the transportation of all types of



radioactive materials — from medical isotopes to nuclear fuel waste — with Transport Canada, which sets the standards for carriers under the *Transportation of Dangerous Goods Act*.

Packaging for safety

Like its counterparts in other countries, the Control Board based its packaging regulations on those developed under the International Atomic Energy Agency of the United Nations. Such regulations require that containers used to ship radioactive materials be proven competent and receive a certificate from the Control Board before they can be used.

The Board does not specify packaging details. Instead, it requires that containers meet certain performance standards, depending upon the amount, physical form, and radiological properties of the material to be contained and transported.

When a design for a package is proposed, prototypes must undergo testing and detailed analysis to ensure they will meet the performance standards established for them. This puts the onus on the package designer to prove to the Control Board that the proposed package will not release its radioactive materials if it is involved in a severe accident. Packages used to transport used reactor fuel must survive:

- A nine-metre drop onto an unyielding surface.
- A one-metre drop onto a 15-centimetre-high steel pin.
- A nine-metre drop of a 500-kilogram steel plate onto the specimen (for light-weight packages).
- A one-half-hour thermal flux test (complete engulfment in an 800-degree-Celsius fire).
- Immersion in 200 metres of water for eight hours.

Testing: Containers in which nuclear fuel waste would be shipped to a disposal site must pass a number of rigorous tests, including a nine-metre drop onto an unyielding surface and a one-metre drop onto a steel pin.

In some countries, packages that passed these tests underwent staged accidents in which they were hit with a locomotive travelling at 165 kilometres per hour, or tied to the front of rail cars and rammed against solid barriers at speeds up to 130 kilometres per hour. In each case, they survived with less damage than when subjected to the nine-metre drop test.

Developing a Canadian container

Used nuclear fuel bundles have been packaged and shipped safely around the world for many years. In Canada, about 500 shipments of limited quantities of used fuel — largely destined for research work — have been made over the past 25 years. The creation of a nuclear fuel waste disposal facility, however, would necessitate the use of containers capable of transporting larger quantities. Such containers have been used in other countries for many years.

Under the Nuclear Fuel Waste Management Program, Ontario Hydro was responsible for developing a nuclear fuel waste shipping container. It produced a massive stainless-steel cask with walls 27 cm (11 inches) thick and a built-in impact limiter encased in stainless steel that insulates the lid seals from the heat of a fire and reduces the impact forces on the cask in the event of an accident. The container is strong and weighs about 35 tonnes. It would be transported on a four-axle, flatbed trailer developed solely for this purpose.

A half-scale model of the cask was built and subjected to the Control Board tests, which it passed.

Shipping the waste

Regardless of the mode of transport selected, once the waste is loaded into a cask for shipment, it would be subject to Control Board regulations. These regulations cover the radiation levels around the outside of the cask, safety marking, securing of the cask to the vehicle (or ship), placarding and other important details.

As part of its compliance program, the Control Board would perform spot verifications of shipments to ensure its regulations were being followed. As well, the shipper would be required to keep detailed records of each shipment to and from the waste disposal facility. (The empty container may also be contaminated with radioactivity.)

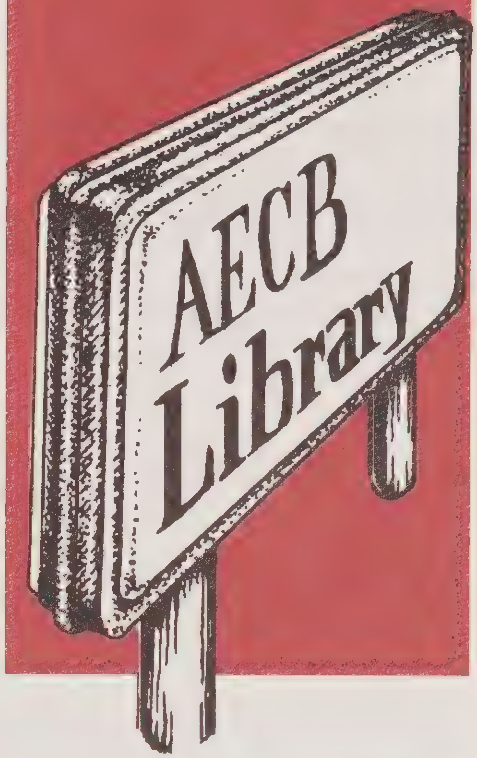
In transit to a disposal site, nuclear fuel waste shipments would also be subject to comprehensive regulations governing the shipment of hazardous goods that have been established by relevant federal and provincial agencies. Ultimately, Canadian and international transportation regulations put the onus on the shipper to carry radioactive materials safely. They stipulate that safety must depend on proper packaging rather than complex handling instructions.

Informing the public

Summary

- The Control Board's regulatory process is open to public scrutiny and comment. All information, except security and proprietary matters, is available to the public.
- The Control Board follows up its information programs by inviting public comment on new proposals for regulations, safety criteria and other major policies before finalizing them.
- At each licensing stage, the Control Board critically assesses every application and makes its assessments available for public comment.
- The Control Board may also convene public meetings in the host communities to provide information on its regulatory criteria and process, and to obtain public comment to assist it in making decisions.

Information: *The Control Board's library in Ottawa is open to the public.*



Introduction

When the governments of Canada and Ontario announced the Nuclear Fuel Waste Management Program, they decided to subject it to "thorough regulatory and public scrutiny." They believed that an informed, active public would contribute to the development of a safe, publicly acceptable nuclear fuel waste disposal system.

The public includes everyone in Canada. And while pro-nuclear and anti-nuclear organizations often take the lead in debating the issues, participation in the program is not limited to these groups nor to scientists and government officials. Anyone with technical, social, economic, or ethical questions, may participate.

The Control Board's public information program

The government's decision to seek public participation in the Nuclear Fuel Waste Management Program dovetails with the Control Board's own fundamental operating philosophy, which hinges on keeping the regulatory process open to public scrutiny and comment.

Almost all the Control Board's information is accessible. On request, the Board's Office of Public Information (OPI) will add your name to its mailing list to receive free copies of your choice of upcoming information materials — regulatory and consultative documents, annual reports, news releases, information bulletins, minutes of board meetings (on microfiche), Publications Catalogue and a quarterly regulatory journal.

And at the Control Board offices in Ottawa, anyone can inspect file information pertaining to the granting or revoking of licences, including supporting documents from licence

applicants, assessments by the Board staff, and other relevant material. Only documents regarding security, or containing proprietary information, remain confidential.

The Control Board also keeps the public informed through media releases about incidents at nuclear facilities, real or potential hazards, plans to open new facilities under Control Board jurisdiction, and at each stage of the licensing process for new projects.

Consultative documents for public comment

Providing information is only part of the effort to involve the public in the regulatory process.

To encourage public participation, the Control Board introduced its Consultative Document System in 1981. Under the system, new proposals for regulations, safety criteria, and other major policies, are made available for public comment before they are finalized as requirements. Anyone who contacts the Board's Office of Public Information and asks to receive them will automatically receive copies of consultative documents as they are issued. The Control Board normally allows 90 days for recipients to review the material and return a written response, which can then be used in the revision process.

Once the Nuclear Fuel Waste Management Program was underway, the Control Board issued four relevant consultative documents, which outlined its general criteria for disposal. After the 90-day comment period, each was carefully reviewed and issued as a regulatory document.

Since no licence to build an actual disposal facility was being sought, the documents pertained only to a generic (non site-specific) facility and provided guidance to AECL, the developer of the disposal concept, and the federal Environmental Assessment Panel, which is evaluating AECL's concept.

During the assessment phases of the program, the Panel will hold hearings to listen to the public's comments on the concept. The Panel will be interested in both comments on the scientific and technical adequacy of the safety case presented in the concept's Environmental Impact Statement, and on the social, economic, environmental and ethical questions associated with the concept.

After the Panel has made its recommendations, the Control Board will review its regulatory documents and modify them as appropriate.

The Board encourages members of the public to learn as much as possible about Canada's Nuclear Fuel Waste Management Program by requesting more information from the organizations involved in the program. Those who have questions, concerns or opinions are urged to express them — either as written submissions or by attending scheduled public meetings.

Inspection: *At the AECB offices, anyone can inspect the information on file.*

Glossary

AEC (Atomic Energy Control) Act Passed in 1946 by Parliament, the act created the Atomic Energy Control Board and gave it broad powers to regulate all facets of nuclear energy in Canada.

Atomic Energy Control Board A federal departmental corporation created under the Atomic Energy Control Act of 1946. With headquarters in Ottawa, it regulates all aspects of nuclear energy in Canada, including waste management facilities.

AECL (Atomic Energy of Canada Limited) A commercial Crown corporation established in 1952 to develop and commercialize peaceful uses for nuclear energy. It conducted the technical assessment of the nuclear fuel waste disposal concept and developed technologies and techniques associated with that concept.

Backfill Material used to fill the shafts and tunnels of a waste repository after the containers of waste have been put into place.

Background radiation Ever-present, natural radiation from radioactive elements in soil, rock, plants, animals, water, etc. It includes solar and cosmic radiation and radiation from radioactive elements in the upper atmosphere.

Buffer Material compacted around containers of nuclear fuel waste in a repository to seal them in and retard the movement of any radionuclides that become dissolved in ground water.

CANDU An acronym for Canada Deuterium Uranium, the distinctive reactor design developed in Canada.

Canadian Nuclear Fuel Waste Disposal Concept The concept is to seal the waste in long-lasting containers and bury it 500 to 1,000 metres deep in a massive rock body in the Canadian Shield. (See generic concept.)

Canadian Shield An extensive area of crystalline rock that lies north of the Great Lakes. The rock is more than a billion years old and has been generally stable for hundreds of millions of years.

Computer modeling In waste management work, it involves using computer programs to indicate the possible behaviour, over long periods of time, of natural and engineered components and systems, such as underground water systems, or artificial barriers created to limit the movement of radionuclides.

Decay Disintegration of the nucleus of an unstable atom by spontaneous emission of particles, electromagnetic radiation, or both.

Decommissioning The process of safely closing a nuclear facility or area and decontaminating it, ideally so the location may be used for other purposes. Decommissioning is a planned stage in the life of a nuclear facility and is regulated by the Atomic Energy Control Board.

Deep geologic disposal concept The concept of placing nuclear fuel wastes into a geologic media, such as salt, chalk, volcanic rock, granite, etc. to isolate and contain them permanently.

Disposal Disposal is the permanent and secure containment of radioactive wastes, with no intention to retrieve them.

Disposal system A comprehensive term, embracing all structures, materials, processes, procedures or other aspects that, taken together, constitute the means by which the safe disposal of the waste is achieved.

Dry storage Storage of nuclear fuel waste in specially constructed above-ground structures. Dry storage is not undertaken in Canada until the waste has lost much of its heat and radiation in water-filled storage facilities over a five- or six-year period.

EAP (Environmental Assessment Panel) A seven-member panel appointed by the federal environment minister in 1989 to review the safety, environmental and socio-economic implications of the Canadian concept of nuclear fuel waste disposal. It will take into account the scientific and technical assessment provided by an independent Scientific Review Group (SRG) and the results of public hearings.

EARP (Environmental Assessment and Review Process) A review and planning process (rather than a regulatory one) for assessing the environmental consequences of proposals requiring a federal government decision. It is administered by the Federal Environmental Assessment Review Office.

EIS (Environmental Impact Statement) A document outlining the results of Atomic Energy of Canada Limited's work to develop its nuclear fuel waste disposal concept against a set of guidelines established by the EAP.

Engineered barrier A man-made or installed barrier to prevent groundwater from contacting the waste and to retard or prevent radioactive substances from moving away from the repository. The Canadian disposal concept includes several engineered barriers -- special waste containers, for example.

Glossary

FEARO (Federal Environmental Assessment Review Office) Administers the Environmental Assessment and Review Process and provides administrative and financial arrangements for environmental assessment panels to fulfill their responsibilities.

Fuel bundle CANDU fuel consists of uranium dioxide pellets, stacked and sealed inside metal tubes. As many as 37 of these tubes, welded together, make a fuel bundle about the size of a fireplace log. Several thousand bundles are needed to fuel a reactor.

Gamma rays/gamma radiation A penetrating type of radiation similar to X-rays that can damage or destroy living cells. Nuclear fuel waste emits extremely hazardous amounts of gamma radiation, which gradually decreases in intensity over time. After about 500 years, most of the gamma radiation has disappeared.

Generic concept The Canadian nuclear fuel waste concept is intended to be a generic feasibility study and proposal in the sense that it is being developed for implementation at any of a number of sites that fit a specific profile.

Groundwater Water that seeps or flows through the ground. Groundwater is important in studying the geologic waste disposal concept because it is the main pathway by which radioactive material could reach the surface.

IAEA (International Atomic Energy Agency) An agency of the United Nations with headquarters in Vienna, Austria. It promotes the safe, peaceful uses of nuclear energy internationally; provides technical support to countries that use nuclear energy for power generation, medicine, agriculture, industry or research; and administers and enforces international treaties aimed at stopping the proliferation of nuclear weapons.

ICRP (International Commission on Radiological Protection) The basis for the Canadian regulatory limits on permissible radiation doses and exposures originates with the recommendations of the ICRP. Established in 1928, it is composed of independent, eminent scientists in the field of radiological protection. ICRP recommendations are accepted worldwide by national and international bodies responsible for radiation protection.

Ionizing radiation When this form of radiation transfers energy, it causes the molecules of the substance it touches to become electrically charged, or ionized. If enough energy is absorbed by living tissue, cells may be damaged or killed. X-rays are a common example of ionizing radiation. Forms of non-ionizing radiation include sunlight, microwaves and radio waves.

Long-lived wastes Wastes that include radioactive elements with half-lives of thousands, or even millions, of years.

Low-level radioactive waste Waste from nuclear operations except used reactor fuel. In addition to various chemical compounds, they include contaminated protective clothing, building materials, and used medical devices.

NEA (Nuclear Energy Agency) The Organization for Economic Co-operation and Development (OECD) created this agency to promote international co-operation in nuclear safety and regulation and to promote nuclear energy as a contributor to economic progress. It encourages countries to exchange scientific and technical information and to harmonize their government regulatory policies and practices. Its headquarters are in Paris, France.

NPT The Treaty on the Non-Proliferation of Nuclear Weapons is an international legally binding instrument dedicated to global peace and security. It entered into force in 1970 and has been signed by 162 non-nuclear weapons states -- including Canada -- and the five nuclear weapons states. Non-nuclear weapons state signatories undertake not to use their nuclear programs to manufacture or acquire nuclear explosives, while nuclear weapons states undertake to work toward nuclear disarmament.

Natural analogues In the context of waste disposal, natural analogues are bodies of uranium ore or other naturally occurring radioactive materials that have remained isolated and immobile in the earth for millions of years. They provide evidence from nature about the processes that will control long-term repository performance. They can also include archaeological objects made of materials similar to those used to construct engineered barriers.

Nuclear fuel waste Used fuel bundles taken from CANDU reactors that are no longer capable of efficiently maintaining the nuclear fission process because they are contaminated with long-lived, highly radioactive elements. Canada's nuclear fuel waste is stored at reactor sites. Also called used fuel or spent fuel.

Nuclear Fuel Waste Management Program Refers to the program announced by the federal and Ontario governments in 1978 to conduct extensive research and development of the deep geologic disposal concept for possible implementation in Canada. Under the program, Atomic Energy of Canada Limited is responsible for all work associated with the concept except in the areas of transportation of nuclear fuel waste and interim storage options, which were assigned to Ontario Hydro.

Glossary

Particle radiation refers to alpha and beta particles, which can scarcely penetrate the outer layer of human skin. They do not pose an external hazard, but a substance emitting these particles can be an internal hazard if swallowed or inhaled. Components of nuclear fuel waste emit these particles.

Pre-closure/post-closure period The pre-closure period is the time during which a site is selected, the repository constructed and the waste put in place, and any time afterwards that the repository is kept open for surveillance or other reasons. The post-closure period begins after the repository is closed.

Radiation A form of energy that travels through space and gives up some or all of its energy upon contact with any material.

Radioactive Material that consists of, or contains, atoms that disintegrate spontaneously (decay) are said to be radioactive because as they decay, they emit ionizing radiation.

Radioisotopes Radioactive forms of an element having the same number of protons but different numbers of neutrons in their nucleus. Isotopes of any particular element have the same chemical properties but different physical properties, such as mass.

Radionuclides Radioactive elements. A term sometimes used interchangeably with radioisotopes.

Reactor A facility or structure in which a controlled nuclear chain reaction takes place.

Release pathways Air and water routes that radioactive contaminants could use to reach the environment from an underground repository.

Repository In the context of the deep geologic disposal of nuclear fuel waste, a repository consists of a man-made underground chamber, or interconnected chambers, carved out of rock, salt, chalk, etc., in which the waste is placed -- plus associated technologies and barriers.

Reprocessing The extraction for recycling of fissionable material from nuclear fuel waste. This process is not currently used in Canada.

Risk In the context of nuclear fuel waste management, risk is defined as the probability that a fatal cancer or serious genetic effect will occur to an individual or his or her descendants.

SRG (Scientific Review Group) Fifteen independent scientists with relevant backgrounds chosen by the Environmental Assessment Panel to help evaluate scientific and technical matters related to the review of the Canadian concept for nuclear fuel waste disposal.

Scoping meetings A series of public meetings held in Ontario, Quebec, New Brunswick, Saskatchewan and Manitoba by the Environmental Assessment Panel to identify commonly held questions and concerns about the Canadian nuclear fuel waste disposal concept. The information obtained at these meetings formed the basis of the guidelines that were given to AECL for the preparation of its Environmental Impact Statement.

Shielding Materials placed around radioactive substances to absorb radiation and reduce radiation exposure.

Short-lived wastes Wastes in which the radioactive elements decay to stable elements in a relatively short time. Many of the radioisotopes used in nuclear medicine fall into this category because they decay in a matter of hours, days or weeks.

Sievert International unit used to measure dose equivalents of different types of radiation. Because the Sievert is a relatively large unit, doses are usually measured in millisieverts (mSv). The average Canadian receives between 2 and 3 mSv a year from natural background radiation.

Site characterization A detailed physical examination of a site proposed for a nuclear fuel waste disposal facility.

Spent fuel Often used interchangeably with nuclear fuel waste or used fuel.

Storage The temporary holding of radioactive wastes in a manner that provides for surveillance, control, and eventual retrieval.

Storage bay Specially constructed, water-filled pool for the safe storage of used fuel. Also referred to as a fuel bay.

Used fuel (See nuclear fuel waste.)

Waste management All activities, administrative and operational, that are involved in the handling, transporting, conditioning, treatment, storage and disposal of radioactive waste.

Where to get additional information

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